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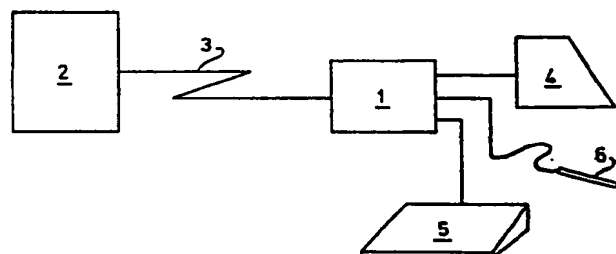
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54 A method and apparatus for continuously updating a display of the coordinates of a light pen.

57 A method and apparatus for continuously updating a display of the coordinates of a light pen as it moves across a display screen involves executing a single iteration of an approximation calculation every refresh cycle of the display. The absolute screen coordinates are updated by the light pen tracking system and converted to application parameters written by the host computer into the display buffer work space. The orthogonal displacements,  $dx$  and  $dy$ , from a fixed reference point are determined. The distance and direction values from the reference point are converted to character form and inserted in the display buffer.



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A METHOD AND APPARATUS FOR CONTINUOUSLY UPDATING  
A DISPLAY OF THE COORDINATES OF A LIGHT PEN

This invention relates to graphic data display systems and particularly to such systems in which the position of a locator such as a light pen is displayed.

Users of graphic data display systems use locators such as light pens for cathode ray tube display or stylus for tablets for drawing on the display area. Engineering drawings generated in this manner are required to be accurate within specified tolerances as the resultant drawing can be used directly to control a manufacturing operation under a so-called CAD/CAM system. One such system is the IBM 7361 Fastdraft System (IBM is a Registered Trade Mark). The IBM 7361 Fastdraft system includes an IBM 3251 display having a keyboard and a light pen, these comprise a draughting workstation. The display screen displays menus and images within a viewing area. When it is needed, a tracking cross for tracking light pen movement is displayed.

In the IBM 3250 Display System because of the time required for calculations, a digital read-out of the distance and direction traversed by a light pen on the refreshed display is not available until the movement of the light pen is complete. The calculation of the distance and angle traversed by the light pen is performed by the host computer after an interrupt to perform the calculation. This interrupt occurs when the light pen reaches its final point. Such a process is too slow to permit the parameters of the light pen position to be continuously displayed during the light pen movement.

The article 'An Improved Light Pen Tracking Algorithm Based on a Recursive Digital Filter' by Murray Kesselman - Proceedings of the S.I.D. Vol. 14/2 Second Quarter 1973 p. 52 et seq describes an algorithm for light pen tracking that can be used in a time sharing environment. The algorithm is only used for tracking and not for providing a display of a light pen position.

A different scheme to identify the position of a light pen is proposed in the article 'Direct-View Storage Tube Light Pen Attachment' by W. F. Beausoleil and R. A. Linton, IBM Technical Disclosure Bulletin Vol. 21, No. 6, November 1978, p. 2450. The direct view storage tube has circuitry which is used to cause the display screen to be scanned by a series of horizontal lines until a pen hit occurs. The co-ordinates of the pen are then transmitted to a host computer. No refresh buffer is required in the terminal to provide the scanning function which is performed in the write through mode.

In order to display the pen position using the Beausoleil-Linton scheme the host computer has to calculate the co-ordinates and transmit the result to the display terminal. As with the IBM 3250 Display System this does not permit a continuously updated display during the movement of the pen.

An object of the present invention is to provide a display of a locator position that changes continuously during the movement of the locator across a display area.

The present invention provides a method and apparatus whereby the light pen position parameters can be determined directly by the local display processor, that is a microprocessor dedicated to controlling the display, so that the light pen position display can be updated each refresh cycle without interrupting and delaying the host computer.

According to the invention there is provided a method of providing a continuously updated display on a display device having a repeating refresh cycle of operations indicating the current position of a locator device in polar coordinates during the movement of the locator device across a display area including the steps of:

- a) obtaining control of the display processor at the end of each refresh cycle

- b) determining the distance and direction of the locator from a fixed reference point
- c) converting the resultant distance and direction values into character form and inserting the characters into a graphic order buffer from which the values will be displayed on the next refresh cycle
- d) returning control to the display processor to start the next refresh cycle.

According to a second aspect of the invention there is provided data display apparatus including a display device having a repeating refresh cycle of operations and means to indicate the current position of a locator device characterised in that the apparatus includes first means operable at the end of each refresh cycle to determine the distance and direction of the locator from a fixed reference point and provide the resultant values, and second means to convert the output of the first means into a character form and to insert the resultant characters into a graphic order buffer from which the values will be displayed on the next refresh cycle whereby the display device displays the current position of the locator device as it moves across a display area.

In order that the invention may be fully understood a preferred embodiment will now be described with reference to the accompanying drawings in which:

FIG. 1 is a block schematic diagram illustrating the components of a directed beam display system.

FIG. 2 is a block schematic diagram illustrating the component parts of a display terminal controller.

The preferred embodiment of the invention is in a directed beam display system such as shown FIG. 1, however the invention finds application in raster beam display devices and in tracking stylii used on graphic tablets having an associated display.

In general terms the invention makes use of the microprocessor in the display controller that is dedicated to controlling the display so that the read-out can be updated each refresh cycle without interrupting and delaying the host computer. The method involves executing a single iteration of a Newton-Raphson approximation every refresh cycle of the display. In the first step the absolute screen co-ordinates are updated by the light pen tracking system and converted to application co-ordinates based on parameters written by the host computer into the display buffer work space. The orthogonal displacements,  $dx$  and  $dy$ , from a fixed reference point (also written in the work space) is determined by subtraction. The maximum of  $dx$  and  $dy$  is then determined.

The distance and direction values from a reference point are then determined, converted into character form and inserted into the display buffer orders. The results are then continuously updated on the screen.

Referring now to Figure 1 in which a block schematic of a display system is shown. A display controller 1 is connected to a host data processing system 2 through a cable link 3. The controller 2 has connections to a display head 4, a keyboard 5, and a light pen 6. The system shown is typical of any IBM 3250 Display System and the controller 2 may also have a graphic tablet and stylus attached.

In such a system the user controls the light pen 6 to indicate portions of the display head screen or to draw lines on the screen. When the system is used for a computer aided design (CAD) then the accuracy with which drawings are generated is important. It is in helping the user to achieve accurate drawings that the invention finds its use.

The display on the display head 4 is controlled by the controller 1. Figure 2 is a block schematic of the portions of the controller which are used for implementing the preferred embodiment of the invention.

Referring now to Figure 2 there is shown a graphic control processor which has output connections to the display head and the light pen on lines 11 and 12 and a display processor 13 which has an input connection from the keyboard on line 14. Both the graphic and display processors are connected to a common bus 15. A store 16 comprising a 32K Random Access Memory (RAM) and a 32K of RAM and Read Only Memory (ROM) is also connected to the common bus 15. An input-output controller 17 which has the line 18 connection to the host computer is also connected to the common bus 15.

The parameter for controlling the current display frame are contained in a refresh buffer which is part of the 32K RAM of store 16. During normal operation the display processor reads out the refresh buffer forty six times a second and the graphic controller thus regenerates the display screen forty six times a second. The control for the display processor is contained in the 32K RAM/ROM of store 16 and includes the control for implementing the present invention. This control may be implemented in a hard wired logic circuit or as microcode stored in that 32K.

The RAM portion of store 16 includes a graphic order buffer into which a display of characters indicating the light pen position with regard to a reference point are placed.

During each refresh cycle the position of the light pen is noted by the graphic control processor and entered into parameter register in the RAM store.

In a directed beam display the refresh cycle is dependant upon the content of the screen. Thus a picture with only a few lines will have a much shorter refresh time than a more complex picture. A maximum

refresh rate of 46 times a second, means that the nominal time for each cycle in 21 milliseconds. When the user is drawing lines the picture will be relatively simple and the processor will not need the 21 milliseconds to perform the refresh. It is the recognition of this factor that allows the implementation of the present invention without requiring additional processing capacity.

In operation of a display system the host computer will provide a menu display from which the user selects the operation that is to be performed. When the user requires to draw a line he points the light pen at the appropriate portion of the displayed menu. The host computer detects the light pen selection. If a 'draw' is required the host computer displays the appropriate pen follower symbol at a predetermined position on the screen. The parameters of the position are loaded into the controllers display buffer and these are used as the reference point for determining the movement of the light pen. The method of the preferred embodiment will now be described. At the end of each refresh cycle the control of the processor is obtained by the control code of the light pen tracking operation, the following steps are taken before the next refresh cycle starts.

#### Step 1

The screen coordinates of the light pen which have been updated by a light pen tracking routine during the previous refresh cycle, are converted, based on parameters written by the host computer into the display buffer, into orthogonal displacements ( $dx$ ,  $dy$ ) in application units from a fixed reference point.

#### Step 2

A comparison is made of  $dx$  and  $dy$  to determine the range in which the required angle falls, such that the tangent ( $t$ ) of an angle less than  $45^\circ$  is calculated.

Step 3

The following table gives the quadrant range of the angle to be calculated (+ x x is = 0°). The maximum length (L) of dx and dy is calculated, as shown in the following table.

<u>dy + dx</u> Result	<u>dy - dx</u> Result	<u>Angle</u>	<u>L</u>	<u>t</u>
+	+	45-135	dy	-dx/dy
-	+	135-225	-dx	dy/dx
-	-	225-315	-dy	dx/-dy
+	-	315- 45	dx	dy/dx

The special cases of dx=dy=0 or t=1 are recognised at this stage, and in these cases the following Step 4 is not needed.

In the general case, finding the polar coordinates is now reduced to finding the angle A and distance D in a right angle triangle in which D is the hypotenuse =  $L \sqrt{1 + t^2}$ , L is the adjacent side to angle A and L.t where  $0 < t < 1$  is the opposite side.

Step 4

The control system then performs a single step of several Newton-Raphson approximations as follows:

- a) Expressing D as  $L(1 + s)$  it is required to solve:

$$(1 + s)^2 = 1 + t^2$$

The appropriate approximation is

$$s' = \frac{s^2 - t^2}{2(1 + s)}$$



- b) Expressing  $u' = \tan (A/2)$  the appropriate approximation is:

$$u' = \frac{tu^2 + t}{2(tu + 1)}$$

- c) Expressing  $v = \tan (A/4)$  the appropriate approximation is:

$$v' = \frac{uv^2 + u}{2(uv + 1)}$$

- d) Expressing  $w = \tan (A/8)$ , the appropriate approximation is:

$$w' = \frac{vw^2 + v}{2(vw + 1)}$$

The result of executing this step on successive display cycles is that  $s$ ,  $u$ ,  $v$ ,  $w$  progressively approach the correct values describing the position of the light pen. If the light pen is moving they will effectively follow it. The range of values for  $w$  permits  $A/8$  to be found with reasonable accuracy using only two terms of the arc tangent expansion. This convergence depends upon the parameters having been initially within certain ranges as follows:

$$\begin{aligned} s &> -1 \\ -1 &< u < +1 \\ -1 &< v < +1 \\ -1 &< w < +1 \end{aligned}$$

#### Step 5

The distance and direction of the light pen from the fixed reference point are calculated using the current approximation of  $s$  and  $w$ . These are then converted into character form and inserted in the graphic order buffer so that the values will be displayed on the next refresh cycle.

Step 6

A check is made to determine whether a new position for the light pen is detected for several cycles, e.g. 4. If there is no new position then steps 4 and 5 are suppressed.

Step 7

Control is returned to the display processor to start the next refresh cycle and to display on the screen an indication of the light pen position in polar coordinates.

## CLAIMS

1. A method of providing a continuously updated display, on a display device having a repeating refresh cycle of operations, indicating the current position of a locator device in polar coordinates, during the movement of the locator device across a display area including the steps of:

- a) obtaining control of the display processor at the end of each refresh cycle
- b) determining the distance and direction of the locator from a fixed reference point
- c) converting the resultant distance and direction values into character form and inserting the characters into a graphic order buffer from which the values will be displayed on the next refresh cycle
- d) returning control to the display processor to start the next refresh cycle.

2. A method as claimed in claim 1 in which step b includes the calculation of the angle and distance of travel of the locator by a series of approximations.

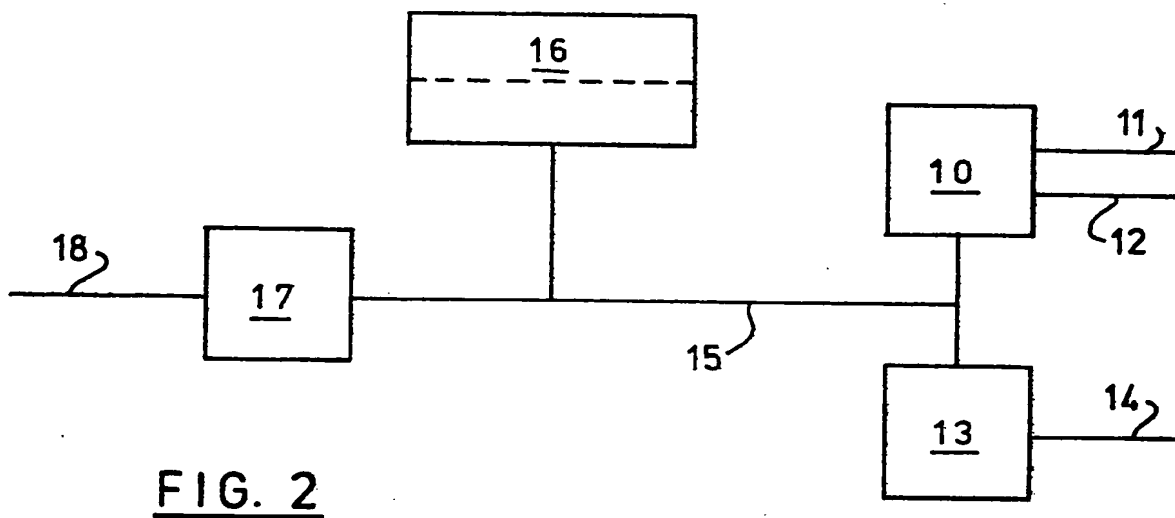
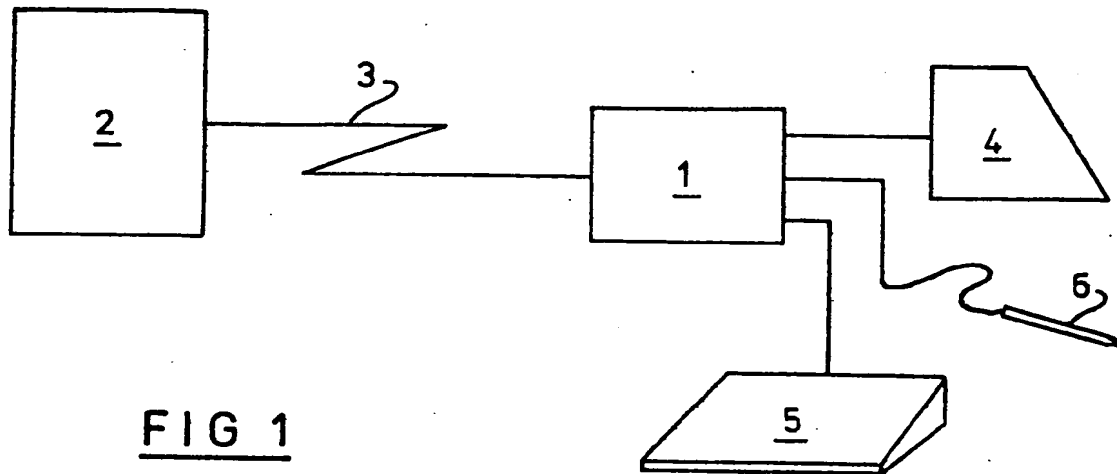
3. Data display apparatus including a display device having a repeating refresh cycle of operations and means to indicate the current position of a locator device characterised in that the apparatus includes, first means operable at the end of each refresh cycle to determine the distance and direction of the locator from a fixed reference point and provide the resultant values, and second means to convert the output of the first means into a character form and to insert the resultant characters into a graphic order buffer from which

the values will be displayed on the next refresh cycle, whereby the display device displays the current position of the locator device as it moves across a display area.

4. Data display apparatus as claimed in claim 3 in which the first means is operable to determine the angle of travel of the light pen and to determine the polar coordinates of the position of the light pen with regard to a reference point by a series of approximation calculations.

5. Data display apparatus as claimed in claim 3 or claim 4 in which the display area is a cathode ray tube and the locator is a light pen.

6. Data display apparatus as claimed in any one of claims 3, 4 or 5 operable to perform the method claimed in claim 1 or claim 2.





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# EUROPEAN SEARCH REPORT

0112415  
Application number

EP 82 30 6864

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	US-A-3 505 666 (INTERNATIONAL BUSINESS MACHINES CORP.) * Abstract; column 1, line 37 - column 2, line 6 *	1,3	G 06 F 3/037
A	--- US-A-3 505 561 (MASSACHUSETTS INSTITUTE OF TECHNOLOGY) * Column 1, line 29 - column 2, line 37 *	1,3	
A	--- COMPUTER, vol. 9, no. 4, April 1976, pages 18-25, Long Beach, USA J. RAYMOND et al.: "Using a microprocessor in an intelligent graphics terminal" * Pages 18,19; figures 1,2 *	1,3	
A	--- PROC. IEE, vol. 123, no. 12, December 1976, pages 1293-1298, Stevenage, G.B. C.R.C.B. PARKER et al.: "High-speed interactive graphical-display system" * Chapters 2.2, 2.3, 2.4, 3.1, 4, 5.1, 5.2, 5.3; figure 4 *	1,3	TECHNICAL FIELDS SEARCHED (Int. Cl. 3) G 06 F G 06 K
A	--- US-A-3 651 508 (SCARBOROUGH Jr. et al.) * Column 5, lines 11-28; column 7, lines 1-6; figures 1,2 *	1,3	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 30-08-1983	Examiner BECKER K.H.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	